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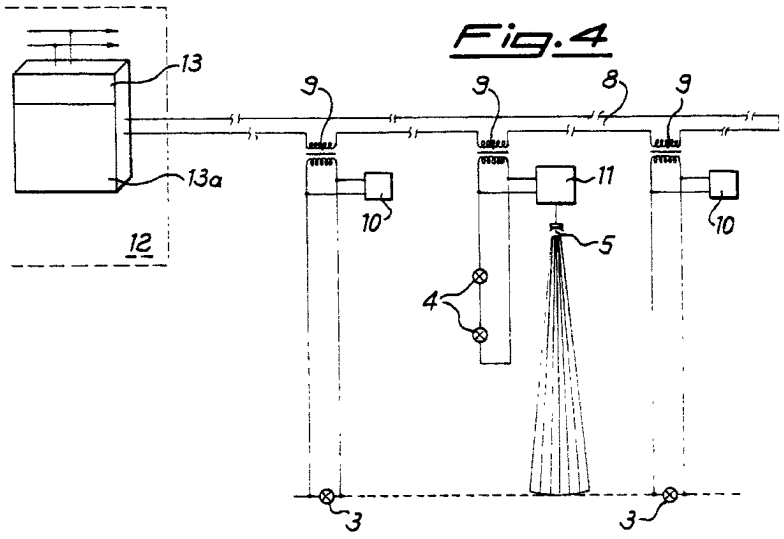
(54) Automatic equipment for controlling and guiding the movement of aircraft travelling on the ground.

(57) Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground on taxi strips (1b), comprising illumination devices (3) disposed at predetermined intervals along the longitudinal axis of the taxi strips (1b); light signalling devices (4) spaced equally apart in such a way that each successive pair of signalling devices (4) defines, in the longitudinal direction, consecutive segments (2) of the taxi strip (1b); devices (5) for detecting the passage of aircraft (6) capable of sending a signal to corresponding means of controlling (10, 13, 14) and displaying (15) the actuation of the sequence of lighting and extinguishing of the illumination and guiding (3) devices and of the light signalling devices (4) of the various segments (2, 102) of the taxi strip (1b).

Fig.4



EP 0 532 110 A2

The present invention relates to equipment for controlling and guiding the movement of aircraft travelling on the ground on taxi strips for access to and exit from the runway and parking and standing areas of airports.

It is known that one of the principal problems relating to the operational management of airports is constituted by the necessity of moving aircraft as rapidly as possible, but in conditions of complete safety, in their transit from the parking area to the take-off runway and from the landing runway to the parking area.

Among the known methods of providing the aircraft pilot with signals permitting proceeding and guiding on predetermined routes of exit from and/or entry to the runways, particular mention may be made of those based on direct visual observation by the pilot of signs located on the ground, manually operated on sight by the control tower operator, and those based on surface radar devices installed at predetermined points at the airport; such devices, however, have numerous disadvantages, including the total lack of control of ground traffic in case of failure or disabling of the device for maintenance operations, or incorrect signalling and/or interpretation of the signalling due to high reflection levels caused by irregularities of the ground, the presence of obstacles, driving rain and the like, image splitting and the like.

Such problems are also significantly increased in critical operating conditions such as those arising with high traffic flows, adverse meteorological conditions and poor visibility.

Consequently there is a technical problem of providing automatic equipment which is capable of signalling to and guiding aircraft during their transit on the ground on sections of taxi and connecting strips, and which is able to ensure a specified safe distance between the aircraft, permitting or refusing their access to sections of taxi strip, and operating reliably in any weather and traffic density conditions, and with a signalling speed proportional to the actual requirements related to the real traffic density in such a way as to cause no significant decrease of the operating capacity of the airport.

The equipment must also be such that correct operation is ensured even in case of failure and/or during ordinary maintenance operations, and such that it may be applied both at new airports and at airports already in operation, by making use, in the latter case, of auxiliary services and transmission lines which may already be in existence.

These results are achieved by the present invention, which provides automatic equipment for controlling and guiding the movement of aircraft travelling on the ground on taxi strips to and from the runways and to and from the standing and parking areas, this equipment comprising in combination illumination devices disposed at predetermined intervals along the longitudinal axis of the taxi strips; light signalling devices spaced equally apart in such a way that each successive pair of signalling devices defines, in the longitudinal direction, consecutive segments of the taxi strip; devices for detecting the transit of aircraft and capable of sending a signal to corresponding means of controlling and displaying the actuation of the sequence of lighting and extinguishing of the illumination and guiding devices and of the light signalling devices of the various segments of the taxi strip, for corresponding permission for or prohibition of the advance of the aircraft along successive segments.

More particularly, it is specified that the said light signalling devices consist of pairs of lights disposed at the lateral edges of the taxi strip on the transverse axes of the segments and that the said detection devices preferably consist of sensors of the microwave and infrared type and consequently that the said sensors illuminate the respective signalling devices when any detection of the passage of the aircraft has ceased.

A further characteristic of the invention consists in the fact that the said control units comprise local control units disposed next to the segments, substation control units disposed inside electrical equipment substations, and central control units disposed in the control tower; in particular, the said substation control units are capable of receiving signals from a central unit and of operating local control units to light and extinguish the axial illumination devices and to extinguish the signalling devices, while the local control units are capable of receiving signals confirming the passage of an aircraft from the sensors and of autonomously causing the lighting of the signalling devices.

In particular, each unilluminated segment is delimited by illuminated red light signals to prevent the access of an aircraft to the said segment.

According to the invention, the automatic equipment may also be used with illumination devices each of which comprises a signalling light and a sensor, each illumination device being capable of operating in this mode, and also as a segment end light, in which case each segment has a minimum length which may be varied as required, and is determined by the lighting of the illumination device with a red light.

For the better use of the equipment it is also specified that the central control unit only controls the intersections delimiting sections of taxi strip and that the local and substation control units directly control the segments into which each of the said taxi strip sections, delimited by consecutive nodes, is divided.

Further details may be obtained from the following description, with reference to the attached drawings, which show:

in Fig. 1:
a partial schematic plan of an airport;
in Fig. 2:
a plan view of a section of taxi strip equipped with signalling devices according to the invention;
in Fig. 3:
a schematic diagram of the local electrical power supply and control circuit of the signalling equipment;
in Fig. 4:
a schematic diagram of the circuit connecting the taxi strip equipment to the substation control unit;
in Fig. 5:
a block diagram of the system of connection of the substation control unit to the central control unit;
in Figs. 6a, 6b, 6c:
the operating sequence of the control and signalling equipment according to the invention;
in Fig. 7:
a view of the device displaying the current state of the ground traffic situation;
in Fig. 8:
an alternative division of the taxi strips into sections delimited by intersections.

As shown in Fig. 1, the map of an airport 1 is normally divided into landing and take-off runways 1a, taxi strips 1b comprising links and intersections 1c, and standing and parking areas 1d.

In order for the aircraft to be guided automatically from the moment at which they leave the landing runway 1a until they stop in the parking area 1d, and vice versa, the taxi strips 1b are, according to the invention, ideally divided into segments 2 adjacent to each other and physically delimited by lighting elements whose lighting and extinguishing are monitored and controlled by programmed control units which receive signals from sensors associated with the lighting elements and send lighting or extinguishing commands to local control units which are in communication with a central unit installed in the control tower.

In greater detail, each segment 2 (Fig. 2) is provided with illuminating elements 3 disposed at predetermined intervals, as will be more clearly specified subsequently, along the longitudinal axis of the segment 2 which is delimited by two opposite theoretical transverse lines 2a constituting the axis of alignment of stop lights 4 associated with sensors 5 capable of detecting the passage of an aircraft 6 and of lighting the stop lights 4 through the local control unit 11, which in turn sends a confirmation signal to a substation control unit 13 located near the taxi strip in corresponding substations 12 (Fig. 4).

The minimum length of a segment 2 is determined on the basis of certain parameters which affect the whole design of the equipment and include the photometric properties of the illuminating elements 3, the characteristic category of authorization for landing, the geometry of the electrical circuits of the light fittings and the dimensions of the aircraft; the power of the lamps and their spacing along the segment, together with the length of the segment itself, will be calculated from these parameters.

As is more clearly shown in Fig. 3, the axial illuminating elements 3 are connected to the series power supply circuits 8 disposed along the taxi strip 1b at its edges, each pair of illuminating elements 3 formed in this way being connected to isolation transformers 9 in parallel to which are connected local control units 10 in order to implement the lighting and extinguishing commands received from the substation control unit 13.

As has been stated, two pairs of stop lights 4 are also installed at each transverse axis of the start and end of a segment 2 near the edge of the taxi strip, these lights also being supplied from the mains 8 through transformers 9, in parallel with which are connected sensors 5 to detect the passage of the aircraft, these sensors also being supplied from the mains 8 through isolation transformers 9.

According to the invention (Fig. 4), the terminals of the electrical circuits are connected to constant current regulators 13a housed in the electrical substations 12, which in turn are connected to substation control units 13 for connection (Fig. 5) to the central control unit 14 which is located in the control tower and substantially consists of a pair of electronic computers 14a arranged in parallel, a monitoring unit 14b capable of determining the priority of operation between the two computers, a data compression unit 14c and an intermediate register 14d for the temporary storage of signals from and to the substation control units 13, installed in the individual substations 12, which operate at a different rate from the central unit 14.

The operating sequence of the equipment is as follows (Fig. 6a): when an aircraft 6a passes through a given segment 2a, all the axial lights 3a of the segment 2a are illuminated to guide the aeroplane and at the same time the red stop lights 4'a, defining the start of segment 2a, are illuminated to prevent any access to the same segment by another aeroplane. During such a phase the axial lights 3b of segment 2b, behind and adjacent to the occupied segment 2a, are extinguished, since the presence of an aeroplane 6, which would be too close to the one in front, is not permitted in

this segment.

If the two segments 2c, 2d following segment 2a are free, the stop lights 4"a disposed next to the transverse end axis of segment 2a permit free passage, being extinguished, and allow the aeroplane 6a to proceed on its way, guided by the corresponding axial lights 3c which will be lighted.

At the same time, a second aeroplane 6b travelling along the same taxi strip behind the aeroplane 6a would find the axial lights 3e of its segment 2e illuminated and the rear stop lights 4'e and forward stop lights 4"e illuminated with red lights to prevent the advance of the aeroplane 6b to the following segment 2b, which would be immediately adjacent to the segment 2a already occupied by the aeroplane 6a and which, in turn, has axial lights 3b extinguished as stated previously.

When the first aeroplane 6a passes the sensor 5a (Fig 6b), the latter, detecting the interruption of the beam, changes state and sends a signal to the substation control unit 13 which, by a dialogue with the central control unit 14, enables the latter to send signals to the local control unit 10 to modify the situation as follows: illumination of the axial lights 3d of segment 2d to allow aeroplane 6a to proceed on its way, on completion of the passage of which in front of the sensors 5'a the situation is further changed as follows (Fig. 6c): axial lights 3c, 3d of the adjacent segments 2c, 2d illuminated and stop lights 4"c extinguished to allow aeroplane 6a to proceed on its way; axial lights 3a of segment 2a to the rear and adjacent extinguished and stop lights 4'a, 4"a illuminated with a red light to prevent access of a second aeroplane to segment 2a, stop lights 4"e extinguished and axial lights 3b of segment 2b illuminated to permit the advance of aeroplane 6b to segment 2b following that being passed through.

Consequently the control of the illumination of consecutive adjacent segments as described above enables the advance of a number of aeroplanes to be guided, while simultaneously ensuring the maintenance of the desired safety distance between one aeroplane and the other, this distance always being measured in multiples of segments 2 of a minimum predetermined length as described above.

The equipment according to the invention is completed by a device for the display of the complete ground traffic situation of the airport, which enables the operators to identify on a video screen 15 (Fig. 7) fixed areas 15a for identification of particular aeroplanes, distinguished for example by their own flight numbers, such fixed areas being associated with a broken line 15b or the like to graphically link the identification area 15a with the segment 2 of taxi strip occupied by the aeroplane and represented on the screen within the map of the airport; as the aeroplane moves along the taxi strip to take off or, in the opposite direction, to the parking area 1d, the identification number will occupy successive fixed areas and change its position on the screen.

Many constructional and dimensional modifications may be introduced into the embodiment of the various components of the equipment without thereby departing from the scope of the invention in its general characteristics; in particular, it is possible to specify the connection of stop light 4 and of the sensor 5 inside each axial illuminating element 3, which in this case will be designed to emit either a green light or a red light, providing, by means of appropriate processing of the data carried out by the corresponding units, continuous control of the whole airport area with the further important possibility of freely modifying the minimum length of segment 2 according to necessity and/or convenience, for example as a result of a decrease in visibility which necessitates a greater safety distance.

It is also possible (Fig. 8) to theoretically divide the map of the airport into sections 102 located between two consecutive intersections, known as nodes, 101c, additionally dividing the tasks of the various control units in such a way that the substation control units 13 have the task of guiding the aeroplane in the individual segments 102 until the final sensor 105 indicates that the aeroplane is entering a node 101c, at which point control passes to the central control unit 14, which is informed of the presence or absence of the other segments leading to this particular intersection, and which may establish the order of precedence of access to the intersection or may divert a machine to other segments; with such a configuration it would be possible to make considerable savings of transmission time, since the data traffic relating to the control of the advance of the aircraft 6 in segments 102 would be limited to the substation control units situated near the taxi strips, while only the data concerning the actual position of each aeroplane would be sent to the central control unit (14).

Claims

1. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground on taxi strips (1b) from and to the runways (1a) and to and from the standing and parking areas (1d), characterized in that it comprises in combination illumination devices (3) disposed at predetermined intervals along the longitudinal axis of the taxi strips (1b); light signalling devices (4) spaced equally apart, in such a way that each pair of successive signalling devices (4) defines, in the longitudinal direction, consecutive segments (2) of taxi strip

(1b); devices (5) for detecting the transit of aircraft (6), capable of sending a signal to corresponding means of control (10, 13, 14) and display (15) of the actuation of the illumination and extinguishing sequence of the illumination and guiding devices (3) and of the light signalling devices (4) of the various segments (2, 102) of the taxi strip (1b), for the corresponding permission for or prohibition of the advance of the aircraft through successive segments (2).

2. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground on taxi strips (1b) according to claim 1, characterized in that the said light signalling devices (4) consist of pairs of lights disposed at the lateral edges of the taxi strip (1b) next to the transverse axes (2a) of the segments (2) del imitating the length of the segments.

3. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground on taxi strips (1b) according to claim 1, characterized in that the said detection devices preferably consist of sensors (5) of the microwave and infrared type, and in that the said sensors illuminate the corresponding signalling devices (4) when any detection of the passage of the aircraft (6) has ceased.

4. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that the said control units comprise local control units (10, 11) disposed next to the segments (2), substation control units (13) disposed inside electrical equipment substations (12), and central control units (14) disposed in the control tower.

5. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that the said substation control units (13) are capable of receiving signals from a central unit (14) and of actuating local control units (10, 11) to illuminate and extinguish the axial illumination devices (3) and to extinguish the signalling devices (4), and in that the said local control units (11) are capable of receiving signals confirming the passage of an aircraft (6) from sensors (5) and of autonomously causing the illumination of the signalling devices (4).

6. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that the said central control unit (14) controls the illumination and extinguishing of the first pair of signalling lights (4) disposed near the accesses to the taxi strip (1b), thus specifying the taxi strip along which the aeroplane has to travel.

7. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that each of the said illumination devices (3) comprises a signalling light (4) and a sensor (5), each illumination device (5) being capable of operating in this mode, and also as a segment end light (2).

8. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claims 1 and 7, characterized in that each segment (2) has a minimum length which may be varied as necessary and is determined by the illumination with red light of the illumination device (3).

9. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that each unilluminated segment is delimited by illuminated red signal lights (4) to prevent the access of an aircraft to this segment.

10. Automatic equipment for controlling and guiding the movement of aircraft (6) travelling on the ground according to claim 1, characterized in that the central control unit (14) controls only the intersections (101c) delimiting sections of the taxi strip (1b), and in that the local control units (10) and substation control units (11) directly control the segments (102) into which each of the said sections of taxi strip delimited by consecutive nodes (101c) is divided.

Fig.1

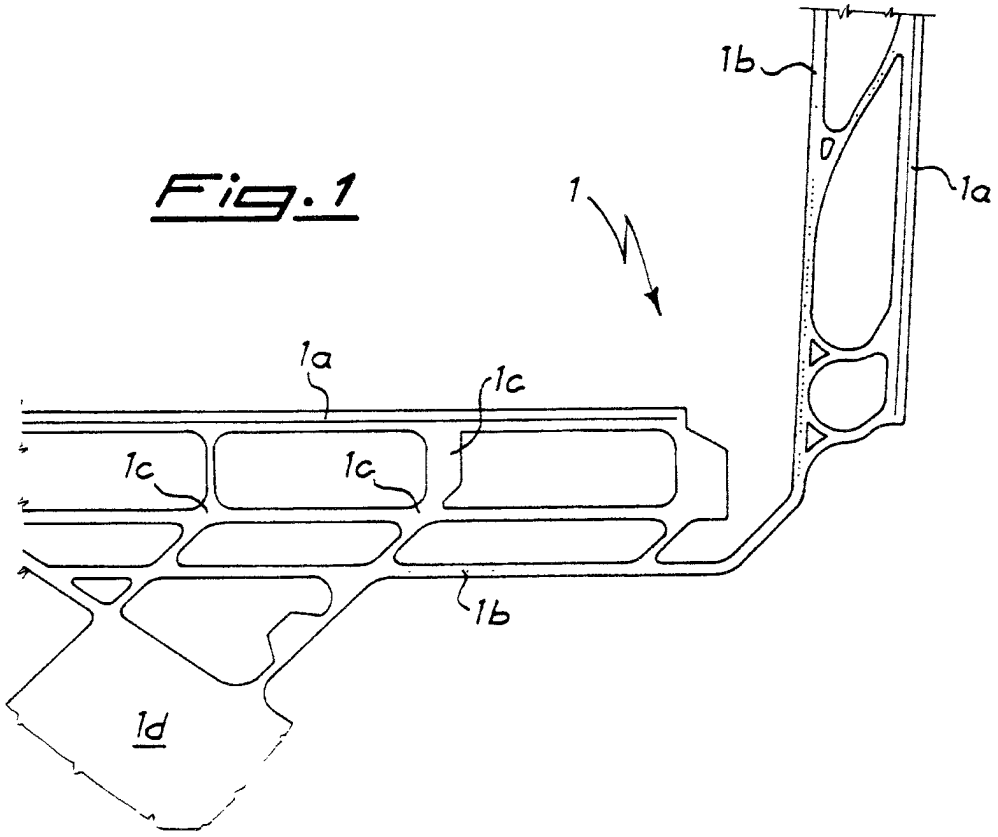
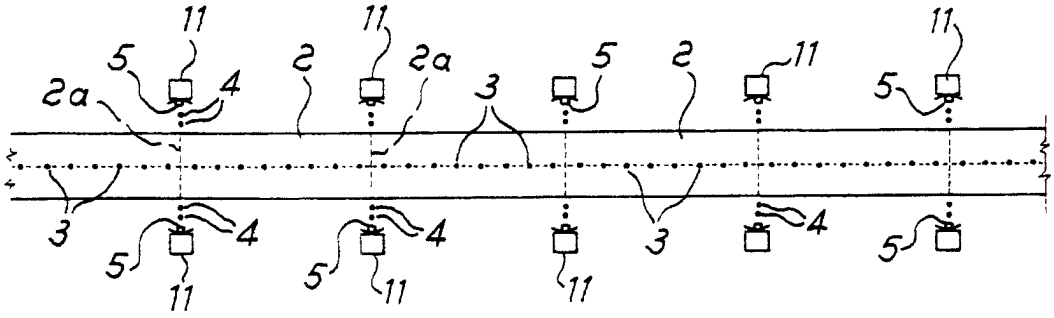

1b
1a
1
1a
1c
1c
1c
1b
1d

Fig.2


11
11
11
11
5
5
5
5
2
2
2
2a
2a
3
3
3
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4
4
4
4
5
5
5
5
11
11
11

Fig.3

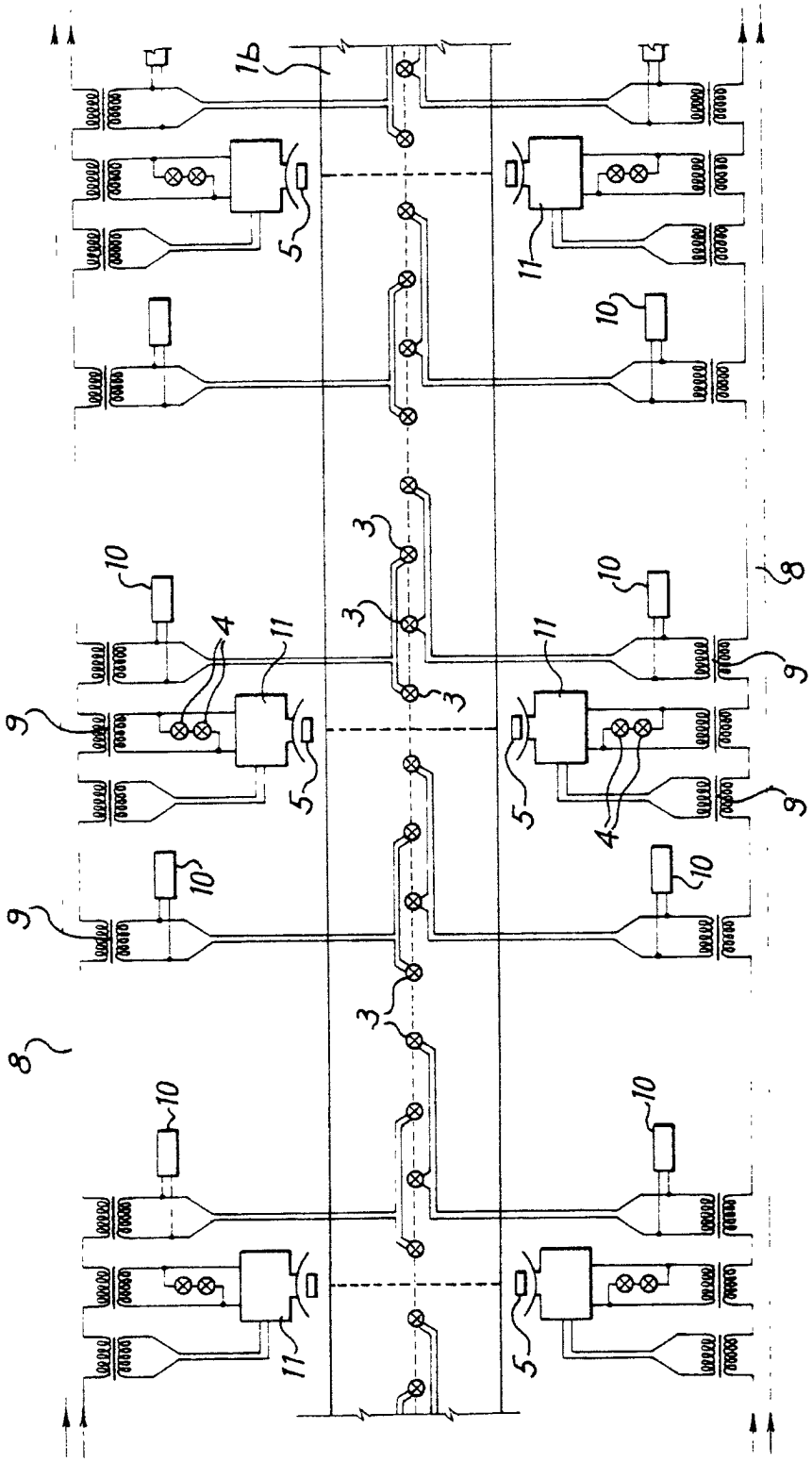
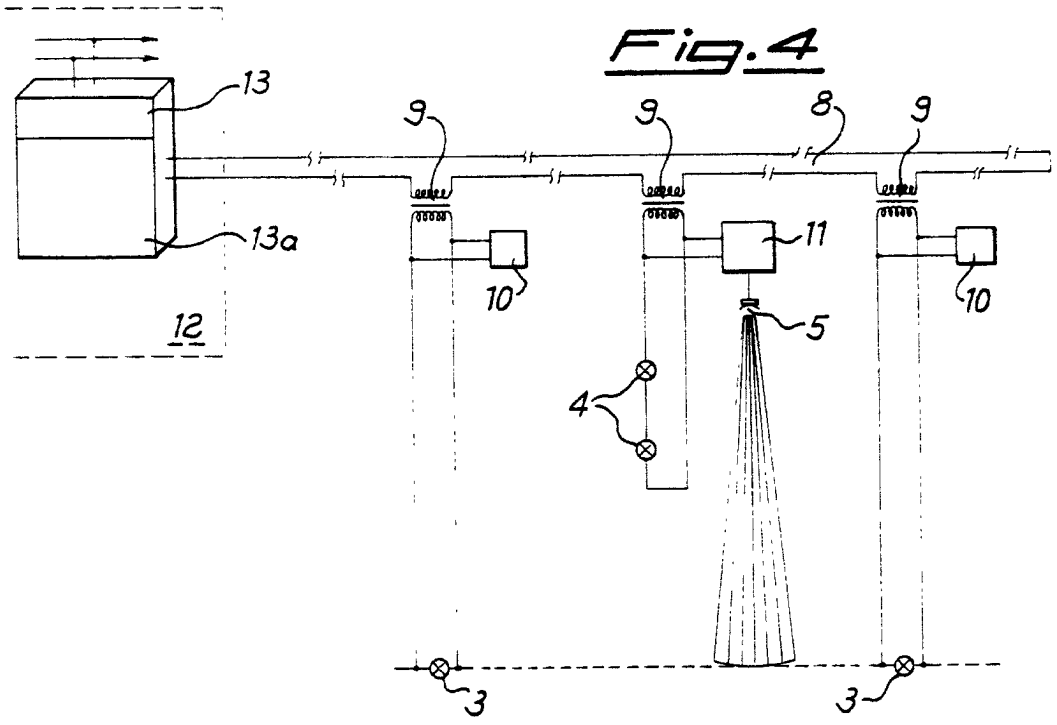


Fig.4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13a
12
9
9
8
9
10
11
10
5
4
3
3

Fig.5

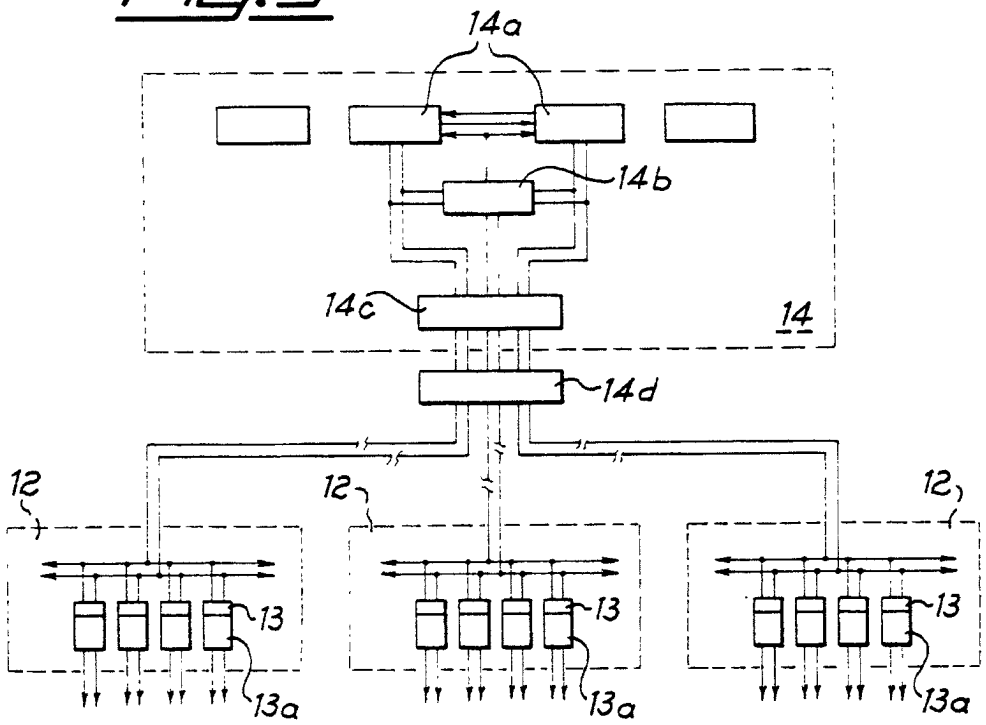
14a
14b
14c
14
14d
12
12
12
13
13
13
13a
13a
13a

Fig.6a

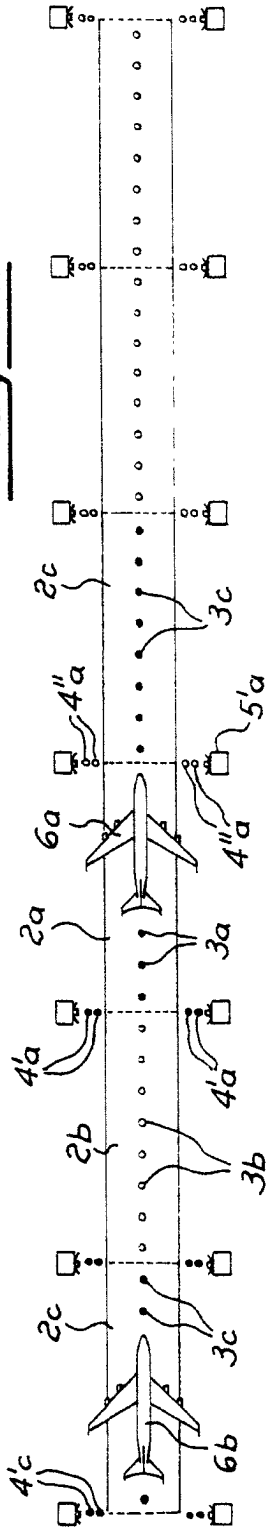

Fig.6b

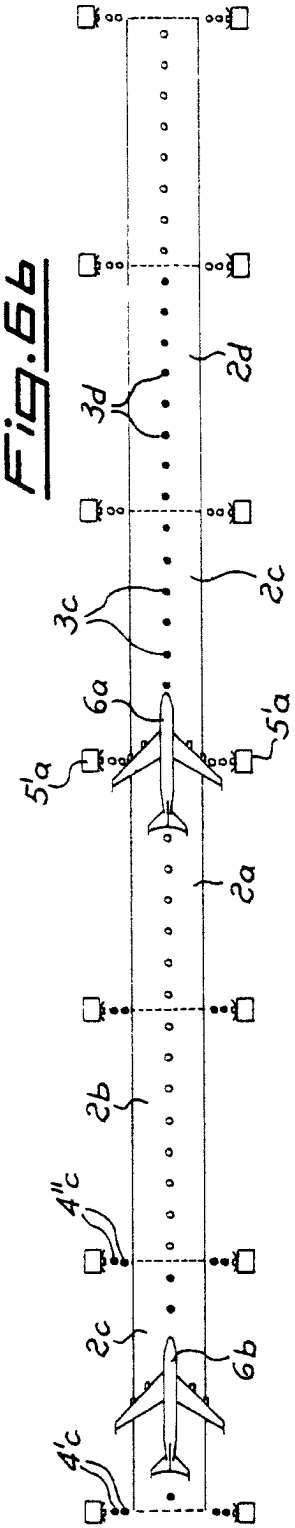

Fig.6c

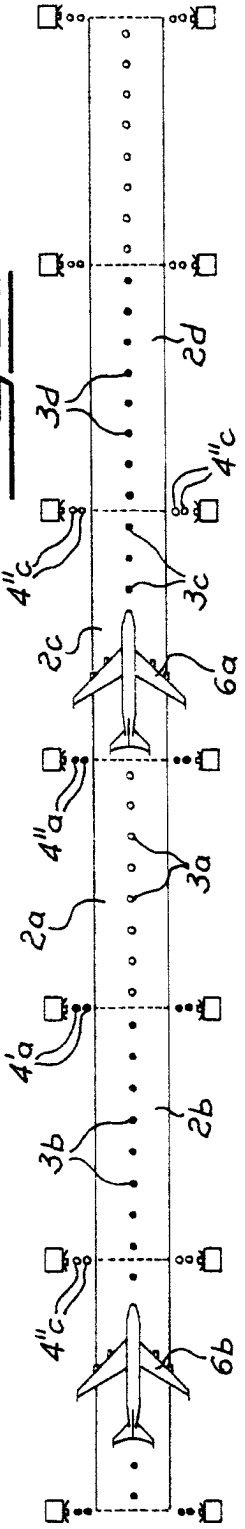

Fig.7

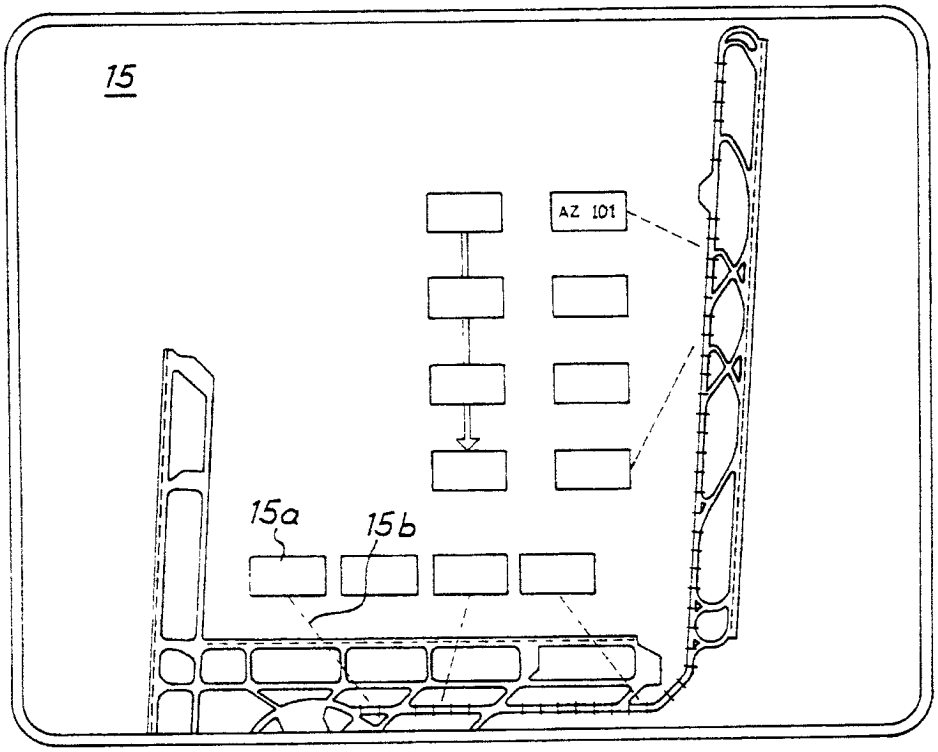

Fig.8